Functional Requirement Specification

PXIE MEBT quadrupoles and dipole correctors

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Revision History

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TABLE OF CONTENTS

1. INTRODUCTION: **4**
2. SCOPE: **4**
3. KEY ASSUMPTIONS, INTERFACES & CONSTRAINTS: **4**
TABLE 1. TYPICAL BEAM PARAMETERS 4
4. REQUIREMENTS **5**
5. REFERENCES: **6**

1. Introduction:

Transverse focusing in the PXIE Medium Energy Beam Transport (MEBT) [1] is made by a set of quadrupole doublets and triplets. For beam steering, each doublet or triplet is equipped with a pair of dipole correctors. This specification describes functional requirements for the MEBT quadrupoles and dipole correctors determined by the optical solution presented in Ref. [2].

2. Scope:

The PXIE MEBT beam optics scheme assumes transverse focusing by 2 quadrupole doublets and 7 triplets, which are composed of two types of quadrupoles, referred in this document as QF and QD. A set of two dipole correctors (to move the beam in horizontal, X and vertical, Y directions) are placed immediately downstream of each doublet or triplet. This specification describes the required magnetic properties of the quadrupoles and dipole correctors as well as their critical dimensions and space limitations.

3. Key Assumptions, Interfaces & Constraints:

Typical beam parameters in MEBT used in optics simulation are listed in Table 1.

Table 1. Typical beam parameters

Ion type	H-
Beam energy	2.1 MeV
Nominal beam current, CW	5mA
Beam normalized transverse rms emittance	0.25 µm
Maximum diameter of the area occupied by beam, 6-sigma + dipole shifts	22 mm
Largest nominal angle made by a dipole corrector	9 mrad

The height of the beam line from the floor is 1300 mm. The transverse dimensions of the quadrupoles (excluding the mounting frame) should not exceed 400mm X 400mm.
Space between quadrupoles is used for BPMs and bellows. The BPMs are connected to cables before installation of quadrupoles. The space that should be left free of winding and other quadrupole elements is shown on Fig. 1 by brown dashed lines.
The MEBT quadrupoles and dipole correctors will conform to FNAL Engineering [3] and ES&H Standards [4].

4. Requirements

Main quadrupole parameters:

Minimum tip separation (diameter) -	34 mm	
Integrated gradient homogeneity in the good field region	1%	
Region of the good field (diameter)-	23 mm	
Maximum integrated gradient-	1.5 T	for Type F
	0.85 T	for Type D
Suggested magnetic length-	10 cm	for Type F
	5 cm	for Type D
Separation between centers of quadrupoles		
in triplets (D+F+D)-	14.5 cm	
in doublets (F+F)-	17 cm	

(corresponds to the distance between iron of 7 cm in both cases)

Dipole correctors:

Each assembly includes two (X and Y) dipole correctors. The assembly should be removable without breaking vacuum for the initial assembly, leak checks, and a possible bakeout. The design should take into account effects resulting from the proximity of the quadrupole and corrector yokes.

Integral of the dipole field-	2.1 mT*m
Region of the good field (diameter)-	23 mm
Integrated field homogeneity in the good field region	5%
Minimum clear aperture (diameter)	75 mm
Available space between the yoke of the nearest quadrupole and a wall of a vacuum box downstream	85 mm

5. References:

Documents with reference numbers listed are in the Project X DocDB: http://projectx-docdb.fnal.gov

[1] Project X and PXIE MEBT Functional Requirements Specification
Document #: Project-X-doc-938

[2] PXIE Optics and Layout, by V. Lebedev, S. Nagaitsev, J.-F. Ostiguy, A. Shemyakin, B. Shteynas, N. Solyak, Proc. of IPAC'12, New Orleans, USA, May 20 - 25, 2012, THPPP057

[3] Fermilab Engineering Manual
http://www.fnal.gov/directorate/documents/FNAL_Engineering_Manual_REVISED_070810.pdf

[4] Fermilab ES&H Manual
http://www-esh.fnal.gov/pls/default/esh_home_page.page?this_page=15053

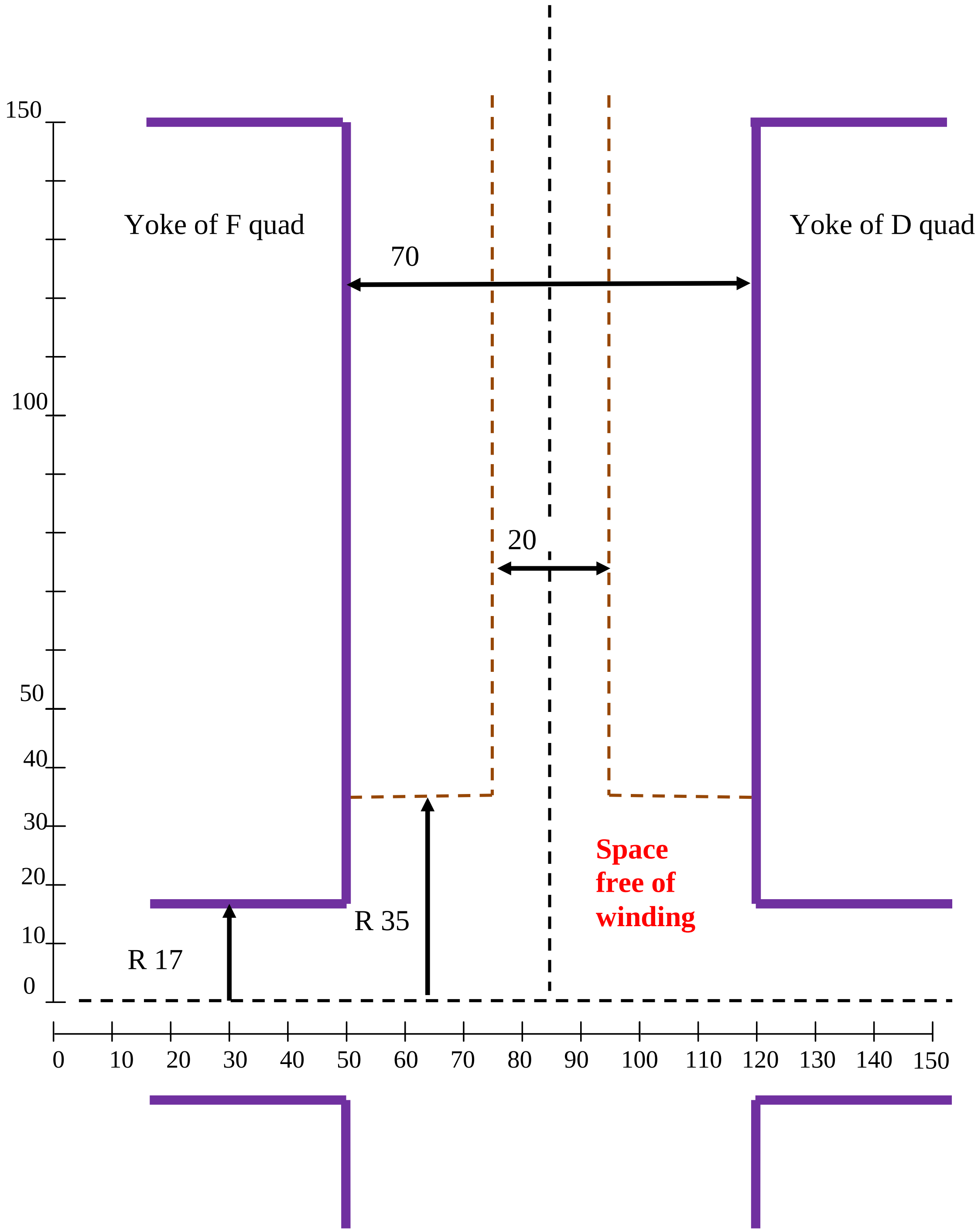

Figure 1. Space between quadrupoles that should be left free of winding for BPMs. All dimensions are in mm. The sketch shows the downstream portion of the triplet; restrictions in the doublets are identical.